Claims

What is claimed is:

1. A method of estimating an injection delay of a fuel injector, comprising:

establishing a baseline injection delay curve representing an injection delay for a predetermined type of fuel injector for a range of rail pressures;

identifying at least one test rail pressure for the predetermined type of fuel injector based on the baseline injection delay curve;

measuring an injection delay of a selected fuel injector of the predetermined type at the at least one test rail pressure; and

estimating the injection delay of the selected fuel injector based on the baseline injection delay curve and the measured injection delay of the selected fuel injector at the identified test rail pressure.

2. The method of claim 1, further including identifying a preferred set of test rail pressures for the predetermined type of fuel injector based on the baseline injection delay curve.

3. The method of claim 1, wherein the baseline injection delay curve represents an average injection delay for the predetermined type of fuel injector for the range of rail pressures.

4. The method of claim 1, wherein the injection delay is measured as an elapsed time between a start of current applied to the injector and a start of fuel injection in response to the current.

5. The method of claim 1, further including populating an injection delay curve for the selected injector based on the baseline injection

delay curve and the measured injection delay of the selected fuel injector at the test rail pressure.

6. The method of claim 2, further including measuring an actual injection delay for each of a plurality of fuel injectors over the range of rail pressures to establish the baseline injection delay curve.

7. The method of claim 6, further including:

estimating an injection delay for each of the plurality of fuel injectors at each of a set of rail pressures based on a numerical comparison of the baseline injection delay curve and the actual injection delay of each of the plurality of fuel injectors at each of the set of rail pressures;

determining an error representing the difference between the estimated injection delay and the baseline injection delay curve for each of the plurality of fuel injectors; and

reselecting the set of rail pressures to reduce the determined error.

8. The method of claim 7, wherein the set of rail pressures are identified as the preferred set of rail pressures when the determined error is below a predetermined tolerance level.

9. The method of claim 1, further including:

identifying a first injection delay for the selected fuel injector for a first rail pressure and a second injection delay for a second rail pressure; and

estimating the injection delay for the selected fuel injector for a third rail pressure based on a first ratio comparing the first injection delay for the selected fuel injector at the first rail pressure to the baseline injection delay curve for the first rail pressure, a second ratio comparing the second injection delay for the selected fuel injector at the second rail pressure to the baseline injection delay curve for the second rail pressure, and a numerical comparison of the first, second, and third rail pressures.

10. A fuel injection control system having an injection delay curve populated according to claim 5.

11. A method of estimating an injection delay for a fuel injector at a particular rail pressure, comprising:

measuring an injection delay for a plurality of fuel injectors of a first type at a plurality of rail pressures;

establishing a baseline injection delay curve for the first type of fuel injector based on the measured injection delay of the plurality of fuel injectors;

measuring a first injection delay for a selected fuel injector of the first type at a first rail pressure and a second injection delay for the selected fuel injector at a second rail pressure; and

estimating a third injection delay for the selected fuel injector for a third rail pressure based on a first ratio comparing the first injection delay for the selected fuel injector at the first rail pressure to the baseline injection delay curve for the first rail pressure, a second ratio comparing the second injection delay for the selected fuel injector at the second rail pressure to the baseline injection delay curve for the second rail pressure, and a numerical comparison of the first, second, and third rail pressures.

12. The method of claim 11, wherein the baseline injection delay curve represents an average injection delay for the first type of fuel injector over a range of rail pressures.

13. The method of claim 11, further including estimating a plurality of injection delays for a plurality of rail pressures.

14. The method of claim 13, further including populating an injection delay curve for the selected fuel injector based on the plurality of estimated injection delays.

15. A fuel injection control system having an injection delay curve populated according to claim 14.

16. A method of identifying a set of test rail pressures for a fuel injector, comprising:

measuring an actual injection delay for each of a plurality of fuel injectors at a first set of rail pressures;

determining a baseline injection delay curve for the plurality of fuel injectors based on the measured actual injection delays at each of the first set of rail pressures;

estimating an injection delay for each of the plurality of fuel injectors at each of a set of test rail pressures based on a numerical comparison of the baseline injection delay curve and the actual injection delay for each of the plurality of fuel injectors at the set of test rail pressures;

determining an error representing the difference between the estimated injection delay amounts and the actual injection delay amounts for each of the plurality of fuel injectors; and

redefining the set of test rail pressures to reduce the determined error.

17. The method of claim 16, wherein the set of test rail pressures is a subset of the first set of rail pressures.

18. The method of claim 16, wherein the set of test rail pressures are redefined until the determined error is below a predetermined tolerance level.

19. The method of claim 16, wherein the estimated injection delay is predicted by at least one of interpolating or extrapolating the estimated injection delay based on a numerical model of the baseline injection delay curve

and the actual injection delay for each of the plurality of fuel injectors at the set of test rail pressures.

20. The method of claim 16, further including:

measuring an injection delay of a selected fuel injector at each of the set of test rail pressure; and

generating an injection delay curve for the selected fuel injector based on the measured injection delay at each of the set of test rail pressures.